

**CLAIMS:**

- 1 1. A method comprising:
  - 2 executing a first instruction in a programmable processor to set a rounding mode;
  - 3 and
  - 4 executing a second instruction within the programmable processor to generate an
  - 5 integer result rounded according to the rounding mode.
- 1 2. The method of claim 1, wherein executing the second instruction comprises
  - 2 executing an instruction that performs a rounded averaging operation.
- 1 3. The method of claim 1, wherein executing the second instruction comprises
  - 2 executing an instruction that performs a non-saturating, fixed-point fractional
  - 3 multiplication operation with rounding.
- 1 4. The method of claim 1, wherein executing the second instruction comprises
  - 2 executing an instruction that performs a right-shift operation with rounding.
- 1 5. The method of claim 1, wherein executing the first instruction comprises
  - 2 executing an instruction that sets a rounding mode selected from a group of rounding
  - 3 modes comprising:
    - 4 rounding toward negative infinity;
    - 5 rounding toward infinity;
    - 6 rounding toward zero;
    - 7 rounding away from zero;
    - 8 rounding to a nearest integer, with a value of one-half being rounded
    - 9 toward negative infinity;
    - 10 rounding to a nearest integer, with a value of one-half being rounded
    - 11 toward infinity;
    - 12 rounding to a nearest integer, with a value of one-half being rounded
    - 13 toward zero; and

14 rounding to a nearest integer, with a value of one-half being rounded away from  
15 zero.

1 6. A method comprising:  
2 performing an operation within a programmable processor to produce a result;  
3 adding a rounding term to the result to obtain an intermediate result, the rounding  
4 term determined at least in part as a function of a rounding mode, a shift amount, and a  
5 sign of the result of the operation; and  
6 right-shifting the intermediate result by the shift amount.

1 7. The method of claim 6, further comprising executing an instruction that sets the  
2 rounding mode.

1 8. The method of claim 7, wherein executing the instruction comprises executing an  
2 instruction that sets a rounding mode selected from the group of rounding modes  
3 comprising:

4 rounding toward negative infinity;

5 rounding toward infinity;

6 rounding toward zero;

7 rounding away from zero;

8 rounding to a nearest integer, with a value of one-half being rounded toward  
9 negative infinity;

10 rounding to a nearest integer, with a value of one-half being rounded toward  
11 infinity;

12 rounding to a nearest integer, with a value of one-half being rounded toward zero;

13 and

14 rounding to a nearest integer, with a value of one-half being rounded away from  
15 zero.

1 9. The method of claim 6, wherein the operation is a rounded averaging operation of  
2 two or four unsigned byte vectors.

1 10. The method of claim 6, wherein the operation is a non-saturating fixed-point  
2 fractional multiplication operation with rounding of a set of vector operands selected  
3 from signed half-word vectors, unsigned half-word vectors, signed word vectors and  
4 unsigned word vectors.

1 11. The method of claim 6, wherein the operation is an arithmetic right-shift  
2 operation on a vector operand by an immediate shift amount with rounding, and wherein  
3 the vector operand comprises a signed byte vector, an unsigned byte vector, a signed  
4 double word or an unsigned double word.

1 12. A method of compiling a software program comprising parsing the software  
2 program to produce instructions executable by a programmable processor, wherein the  
3 instructions include a first instruction that sets a rounding mode, and a second instruction  
4 that performs an arithmetic operation yielding an integer result rounded according to the  
5 rounding mode.

1 13. The method of claim 12, wherein the second instruction performs a rounded  
2 averaging operation.

1 14. The method of claim 12, wherein the second instruction performs a non-saturating  
2 fixed-point fractional multiplication operation with rounding.

1 15. The method of claim 12, wherein the second instruction performs a right-shift  
2 operation with rounding.

1 16. The method of claim 12, wherein the first instruction sets a rounding mode  
2 selected from the group of rounding modes comprising:  
3 rounding toward negative infinity;  
4 rounding toward infinity;  
5 rounding toward zero;  
6 rounding away from zero;  
7 rounding to a nearest integer, with a value of one-half being rounded toward  
8 negative infinity;

9 rounding to a nearest integer, with a value of one-half being rounded toward  
10 infinity;  
11 rounding to a nearest integer, with a value of one-half being rounded toward zero;  
12 and  
13 rounding to a nearest integer, with a value of one-half being rounded away from  
14 zero.

1 17. A method of compiling a software program comprising parsing the software  
2 program to produce instructions executable by a programmable processor, wherein the  
3 instructions cause the programmable processor to:

4 perform an arithmetic operation;  
5 add a rounding term to a result of the arithmetic operation to obtain an  
6 intermediate result, the rounding term determined at least in part as a function of a  
7 rounding mode, a shift amount, and a sign of the result of the arithmetic operation; and  
8 right-shift the intermediate result by the shift amount.

1 18. The method of claim 17, wherein the software program further comprises  
2 processor-executable instructions for executing an instruction that sets the rounding  
3 mode.

1 19. The method of claim 18, wherein executing the instruction comprises executing  
2 an instruction that sets a rounding mode selected from the group of rounding modes  
3 comprising:

4 rounding toward negative infinity;  
5 rounding toward infinity;  
6 rounding toward zero;  
7 rounding away from zero;  
8 rounding to a nearest integer, with a value of one-half being rounded toward  
9 negative infinity;  
10 rounding to a nearest integer, with a value of one-half being rounded toward  
11 infinity;

12 rounding to a nearest integer, with a value of one-half being rounded toward zero;  
13 and  
14 rounding to a nearest integer, with a value of one-half being rounded away from  
15 zero.

1 20. The method of claim 17, wherein the arithmetic operation is a rounded averaging  
2 operation of two or four unsigned byte vectors.

1 21. The method of claim 17, wherein the arithmetic operation is a non-saturating  
2 fixed-point fractional multiplication operation with rounding of a set of vector operands  
3 selected from signed half-word vectors, unsigned half-word vectors, signed word vectors  
4 and unsigned word vectors.

1 22. The method of claim 17, wherein the arithmetic operation is an arithmetic right-  
2 shift operation on a vector operand by an immediate shift amount with rounding, wherein  
3 the vector operand comprises a signed byte vector, an unsigned byte vector, a signed  
4 double word or an unsigned double word.

1 23. A processor-readable medium having processor-executable instructions for:  
2 executing a first instruction in a programmable processor to set a rounding mode;  
3 and  
4 executing a second instruction within the programmable processor to generate an  
5 integer result rounded according to the rounding mode.

1 24. The processor-readable medium of claim 23, wherein executing the second  
2 instruction comprises executing an instruction that performs a rounded averaging  
3 operation.

1 25. The processor-readable medium of claim 23, wherein executing the second  
2 instruction comprises executing an instruction that performs a non-saturating fixed-point  
3 fractional multiplication operation with rounding.

1 26. The processor-readable medium of claim 23, wherein executing the second  
2 instruction comprises executing an instruction that performs a right-shift operation with  
3 rounding.

1 27. The processor-readable medium of claim 23, wherein executing the first  
2 instruction comprises executing an instruction that sets a rounding mode selected from  
3 the group of rounding modes comprising:  
4     rounding toward negative infinity;  
5     rounding toward infinity;  
6     rounding toward zero;  
7     rounding away from zero;  
8     rounding to a nearest integer, with a value of one-half being rounded toward  
9 negative infinity;  
10     rounding to a nearest integer, with a value of one-half being rounded toward  
11 infinity;  
12     rounding to a nearest integer, with a value of one-half being rounded toward zero;  
13 and  
14     rounding to a nearest integer, with a value of one-half being rounded away from  
15 zero.

1 28. A processor-readable medium having processor-executable instructions for:  
2 performing an arithmetic operation;  
3 adding a rounding term to a result of the arithmetic operation to obtain an  
4 intermediate result, the rounding term determined at least in part as a function of a  
5 rounding mode, a shift amount, and a sign of the result of the arithmetic operation; and  
6 right-shifting the intermediate result by the shift amount.

1 29. The processor-readable medium of claim 28, further comprising processor-  
2 executable instructions for executing an instruction that sets the rounding mode.

1 30. The processor-readable medium of claim 29, wherein executing the instruction  
2 comprises executing an instruction that sets a rounding mode selected from the group of  
3 rounding modes comprising:

4       rounding toward negative infinity;

5       rounding toward infinity;

6       rounding toward zero;

7       rounding away from zero;

8       rounding to a nearest integer, with a value of one-half being rounded toward  
9 negative infinity;

10      rounding to a nearest integer, with a value of one-half being rounded toward  
11 infinity;

12      rounding to a nearest integer, with a value of one-half being rounded toward zero;

13 and

14      rounding to a nearest integer, with a value of one-half being rounded away from  
15 zero.

1 31. The processor-readable medium of claim 28, wherein the arithmetic operation is a  
2 rounded averaging operation of two or four unsigned byte vectors.

1 32. The processor-readable medium of claim 28, wherein the arithmetic operation is a  
2 non-saturating fixed-point fractional multiplication operation with rounding of a set of  
3 vector operands selected from signed half-word vectors, unsigned half-word vectors,  
4 signed word vectors and unsigned word vectors.

1 33. The processor-readable medium of claim 28, wherein the arithmetic operation is  
2 an arithmetic right-shift operation on a vector operand by an immediate shift amount with  
3 rounding, wherein the vector operand comprises a signed byte vector, an unsigned byte  
4 vector, a signed double word or an unsigned double word.

1 34. A processor, comprising:

2       a control register to store a rounding mode of a first instruction;

3       a functional unit; and

4           a control unit to direct the functional unit to perform an arithmetic function  
5        according to the rounding mode in response to a second instruction.

1   35.   The processor of claim 34, wherein the second instruction comprises a rounded  
2        averaging operation.

1   36.   The processor of claim 34, wherein the second instruction comprises a non-  
2        saturating fixed-point fractional multiplication operation with rounding.

1   37.   The processor of claim 34, wherein the second instruction comprises a right-shift  
2        operation with rounding.

1   38.   The processor of claim 34, further comprising:  
2        a fetch unit configured to receive an instruction from an instruction stream;  
3        a decode unit configured to decode the received instruction; and  
4        a register file coupled to the plurality of functional units and configured to store  
5        the integer result.

1   39.   The processor of claim 34, wherein the first instruction sets a rounding mode  
2        selected from the group of rounding modes comprising:  
3           rounding toward negative infinity;  
4           rounding toward infinity;  
5           rounding toward zero;  
6           rounding away from zero;  
7           rounding to a nearest integer, with a value of one-half being rounded toward  
8        negative infinity;  
9           rounding to a nearest integer, with a value of one-half being rounded toward  
10      infinity;  
11        rounding to a nearest integer, with a value of one-half being rounded toward zero;  
12        and  
13           rounding to a nearest integer, with a value of one-half being rounded away from  
14        zero.

1   40.   A processor, comprising:

2           a control unit comprising a control register configured to store a representation of  
3        a selected rounding mode;  
4           at least one functional unit coupled to the control register;  
5           a fetch unit configured to receive an instruction from an instruction stream;  
6           a decode unit configured to decode the received instruction; and  
7           a register file coupled to the plurality of functional units,  
8        the control unit configured to  
9              perform an arithmetic operation,  
10             add a rounding term to a result of the arithmetic operation to obtain an  
11        intermediate result, the rounding term determined at least in part as a function of the  
12        selected rounding mode, a shift amount, and a sign of the result of the arithmetic  
13        operation,  
14             right-shift the intermediate result by the shift amount to generate a  
15        rounded result, and  
16             store the rounded result in the register file.

1       41.   The processor of claim 40, wherein the control unit is further configured to  
2        execute an instruction that sets the rounding mode.

1       42.   The processor of claim 41, wherein the instruction sets a rounding mode selected  
2        from the group of rounding modes comprising:  
3           rounding toward negative infinity;  
4           rounding toward infinity;  
5           rounding toward zero;  
6           rounding away from zero;  
7           rounding to a nearest integer, with a value of one-half being rounded toward  
8        negative infinity;  
9           rounding to a nearest integer, with a value of one-half being rounded toward  
10      infinity;  
11           rounding to a nearest integer, with a value of one-half being rounded toward zero;  
12      and

13 rounding to a nearest integer, with a value of one-half being rounded away from  
14 zero.

1 43. The processor of claim 40, wherein the arithmetic operation is a rounded  
2 averaging operation of two or four unsigned byte vectors.

1 44. The processor of claim 40, wherein the arithmetic operation comprises  
2 performing a non-saturating fixed-point fractional multiplication operation with rounding  
3 of a set of vector operands selected from signed half-word vectors, unsigned half-word  
4 vectors, signed word vectors and unsigned word vectors.

1 45. The processor of claim 40, wherein the arithmetic operation is an arithmetic right-  
2 shift operation on a vector operand by an immediate shift amount with rounding, wherein  
3 the vector operand comprises a signed byte vector, an unsigned byte vector, a signed  
4 double word or an unsigned double word.

1 46. A system comprising:  
2 a memory; and  
3 a processor comprising  
4 a control register to store a rounding mode of a first instruction,  
5 a functional unit, and  
6 a control unit to direct the functional unit to perform an arithmetic  
7 function according to the rounding mode in response to a second instruction.

1 47. The system of claim 46, wherein the second instruction comprises a rounded  
2 averaging operation.

1 48. The system of claim 46, wherein the second instruction comprises a non-  
2 saturating fixed-point fractional multiplication operation with rounding of a set of vector  
3 operands selected from signed half-word vectors, unsigned half-word vectors, signed  
4 word vectors and unsigned word vectors.

1 49. The system of claim 46, wherein the second instruction comprises a right-shift  
2 operation with rounding.

1 50. The system of claim 46, wherein the rounding mode is selected from the group of  
2 rounding modes comprising:

3 rounding toward negative infinity;

4 rounding toward infinity;

5 rounding toward zero;

6 rounding away from zero;

7 rounding to a nearest integer, with a value of one-half being rounded toward  
8 negative infinity;

9 rounding to a nearest integer, with a value of one-half being rounded toward  
10 infinity;

11 rounding to a nearest integer, with a value of one-half being rounded toward zero;

12 and

13 rounding to a nearest integer, with a value of one-half being rounded away from  
14 zero.

1 51. A system, comprising:

2 a memory; and

3 a processor coupled to access the memory, the processor comprising

4 a control unit comprising a control register configured to store a

5 representation of a selected rounding mode,

6 at least one functional unit coupled to the control register,

7 a fetch unit configured to receive an instruction from an instruction

8 stream,

9 a decode unit configured to decode the received instruction, and

10 a register file coupled to the plurality of functional units,

11 the control unit configured to

12 perform an arithmetic operation,

13 add a rounding term to a result of the arithmetic operation to obtain

14 an intermediate result, the rounding term determined at least in part as a function of the

15 selected rounding mode, a shift amount, and a sign of the result of the arithmetic

16 operation,

right-shift the intermediate result by the shift amount to generate a rounded result, and store the rounded result in the register file.

1    52. The system of claim 51, wherein the processor is further configured to execute an  
2    instruction that sets the rounding mode.

1       53. The system of claim 52, wherein executing the instruction comprises executing an  
2 instruction that sets a rounding mode selected from the group of rounding modes  
3 comprising:

4 rounding toward negative infinity;

5 rounding toward infinity;

6 rounding toward zero;

7 rounding away from zero;

rounding to a nearest integer, with a value of one-half being rounded toward negative infinity;

10 rounding to a nearest integer, with a value of one-half being rounded toward  
11 infinity;

12 rounding to a nearest integer, with a value of one-half being rounded toward zero;  
13 and

14 rounding to a nearest integer, with a value of one-half being rounded away from  
15 zero.

1 54. The system of claim 51, wherein the arithmetic operation is a rounded averaging  
2 operation of two or four unsigned byte vectors.

1       55. The system of claim 51, wherein the arithmetic operation is a non-saturating  
2 fixed-point fractional multiplication operation with rounding of a set of vector operands  
3 selected from signed half-word vectors, unsigned half-word vectors, signed word vectors  
4 and unsigned word vectors.

1 56. The system of claim 51, wherein the arithmetic operation is an arithmetic right-  
2 shift operation on a vector operand by an immediate shift amount with rounding, wherein

3 the vector operand comprises a signed byte vector, an unsigned byte vector, a signed  
4 double word or an unsigned double word.